

UNITED STATES MARINE CORPS
Logistics Operations School
Marine Corps Combat Service Support Schools
PSC Box 20041
Camp Lejeune, North Carolina 28542-0041

FESCR 8210

STUDENT HANDOUT

REPAIR CATERPILLAR FUEL INJECTION PUMPS

LEARNING OBJECTIVE

1. Terminal Learning Objective: Given a Caterpillar fuel injection pump, the required common and special tools, test equipment, repair parts, shop supplies, RS-08757A-50, and Caterpillar service manuals, per information contained in the references, repair the fuel injection pump. (8.2.8)
2. Enabling Learning Objectives: Given a Caterpillar fuel injection pump, the required common and special tools, test equipment, repair parts, shop supplies, RS-08757A-50, and Caterpillar service manuals, per information contained in the references:
 - a. disassemble the fuel injection pump, (8.2.8a)
 - b. inspect the disassembled components for serviceability, (8.2.8b)
 - c. repair or replace the unserviceable components, (8.2.8c)
 - d. assemble the fuel injection pump, and (8.2.8d)
 - e. calibrate the fuel injection pump. (8.2.8e)

OUTLINE

1. DESIGN CHARACTERISTICS AND PRINCIPLES OF OPERATION OF THE CATERPILLAR SCROLL INJECTION PUMP

a. Design Characteristics

(1) The Caterpillar Scroll type injection pump is used on various types of Marine Corps engineer equipment, such as bulldozers, road graders and cranes. The six, scroll type injection pumps in the main pump housing supply fuel under a high pressure to the six fuel nozzles in the engine. There is one fuel injection pump for each cylinder in the engine.

(2) The injection pump incorporates a fuel transfer pump located on the side of the main pump housing. The transfer pump draws fuel from the vehicle fuel tank and delivers it to the main pump housing.

(3) The governor housing is located behind the main pump housing and houses all of the governor components. Directly behind the governor housing is the air-fuel ratio control. The air-fuel ratio control limits smoke from the exhaust during acceleration.

b. Principles of Operation

(1) Injection Pump

(a) Fuel is pulled from the fuel tank through the primary fuel filter and check valves by the transfer pump. Then, from the transfer pump the fuel is pushed through the secondary filter to the fuel manifold in the injection pump housing. The pumping spring, located in the transfer pump, keeps the fuel pressure in the system at 25 to 42 psi.

(b) The constant bleed orifice, located in the top of the housing, lets a constant flow of fuel go through the fuel return line back to the fuel tank. This helps keep the fuel cool and free of air.

(c) The fuel injection pumps get fuel from the fuel manifold, increase the pressure of the fuel, and then send an exact amount of fuel to the fuel nozzles.

(d) The injection pumps are operated by cam lobes on the pump camshaft, which is located directly under the injection pumps. When the camshaft turns, the lobe pushes the lifter and pump plunger up to the top of its stroke. The pump plunger always makes a full stroke. As the camshaft turns, the spring located within the pump returns the plunger and lifter back to the bottom of the stroke.

(e) When the pump plunger is at the bottom of the stroke, fuel at transfer pump pressure enters into the inlet passage located near the top of the pump, around the pump barrel, and to the bypass port, and fills the area above the pump plunger.

(f) Then, after the pump plunger begins the upward stroke, fuel will be pushed out the bypass port until the top of the pump plunger closes the port. As the pump plunger travels further upward, the pressure of the fuel increases. At approximately 100 psi, a check valve in the pump barrel above the plunger opens and lets fuel flow into the fuel injection line to the fuel nozzles.

(g) As the pump plunger travels further upward, the scroll uncovers the spill port. The fuel above the pump plunger goes through the slot along the edge of the scroll, out the spill port, and back to the fuel manifold. This is the end of the injection stroke.

(h) When the pump plunger travels down and uncovers the bypass port, fuel begins to fill the area above the pump plunger again and the pump is ready to begin another stroke.

(i) The amount of fuel the injection pump sends to the nozzle is changed by the rotation of the pump plunger. Each pump has a plunger gear attached to it and meshed with the fuel rack. The governor moves the fuel rack according to the fuel needs of the engine. When the governor moves the fuel rack, the fuel rack turns the pump plungers. Then the scroll changes the distance the pump plunger pushes fuel between the bypass port and the spill port opening. The longer the distance from the top of the pump plunger to the point where the scroll uncovers the spill port, the more fuel will be injected.

(j) To stop the engine, the pump plunger is rotated so the slot on the pump plunger is in line with the spill port. The fuel will now go out the spill port and not to the nozzle.

(2) Transfer Pump. The fuel transfer pump is a piston type pump that is operated by a cam lobe on the injection pump camshaft. The pump is located on the bottom side of the injection pump housing. The transfer pump will remain on the engine when the injection pump is turned in for repairs.

(3) Oil Flow for Pump and Governor

(a) Oil under pressure from the engine lubrication system enters from the engine block to the bottom of the front governor housing and from there the flow of oil goes in three different directions.

(b) Part of the oil goes to the rear camshaft bearing in the fuel pump housing. The bearing has a groove around the inside diameter, and the oil travels through the groove and into the oil passage in the bearing surface (journal) of the camshaft. A drilled passage through the center of the camshaft allows the oil to travel to the front camshaft bearing and on to the thrust face of the camshaft drive gear.

(c) A drain hole in the front of the injection pump housing keeps the level of the oil in the housing even with the center of the camshaft. The oil then returns to the oil pan through the timing gear housing.

(d) Oil also goes from the bottom of the front governor housing through a passage to the fuel pump housing and to the governor servo. the governor servo gives hydraulic assistance to move the fuel rack and will be discussed in detail later on.

(e) The remainder of the oil goes through a passage to the rear of the rear governor housing, through the air-fuel ratio control and then back into another passage in the rear governor housing. Then the oil goes into the compartment for the governor controls. A drain hole keeps the oil at the correct level. The oil in this compartment is used for lubrication of the governor control components and is the supply for the dashpot.

(f) The internal parts of the governor are lubricated by oil leakage from the servo and the oil is thrown by the rotation of the parts. The flyweight carrier thrust bearing gets its oil from the passage at the rear of the camshaft. The oil from the governor returns to the oil pan through a hole

in the bottom of the front governor housing and through passages in the support and cylinder block.

(4) Governor

(a) The governor controls the amount of fuel needed by the engine to maintain a desired rpm.

(b) The governor flyweights are driven directly by the fuel pump camshaft. The riser is moved by the flyweights and governor spring. A lever connects the riser with a sleeve, which is fastened to a valve that is part of the governor servo, and moves the piston and fuel rack. The fuel rack moves towards the front of the injection pump housing when moved in the "FUEL OFF" direction.

(c) The force of the governor spring always pushes to give more fuel to the engine. The centrifugal (rotating) force of the flyweights always pushes to get a reduction of fuel to the engine. When these two forces are in balance, the engine runs at a constant rpm.

(d) When the engine is started and the governor is at the low idle position, the overfueling spring moves the riser forward and gives an extra amount of fuel to the engine. Then, after the engine has started and begins to run, the flyweight force becomes greater than the force of the overfueling spring. The riser moves to the rear and reduces the amount of fuel to the low idle requirement of the engine.

(e) When the governor control lever is moved to the high idle position, the governor spring is put in compression and pushes the riser toward the flyweights. When the riser moves forward, the governor control lever moves the sleeve and valve toward the rear. The valve then stops oil flow through the governor servo and the oil pressure moves the piston and fuel rack to the rear. This movement increases the amount of fuel to the engine. As the engine speed increases, the flyweight force increases and moves the riser towards the governor spring. When the riser moves to the rear, the lever moves the sleeve and valve forward. Now, the valve directs oil pressure to the rear of the piston which moves the piston and fuel rack forward. This decreases the amount of fuel to the engine. When the flyweight force and the governor spring force become equal, the engine speed is constant and the engine runs at high idle rpm. High idle rpm is adjusted by the high idle adjustment screw. The adjustment screw limits the amount of compression of the governor spring.

(f) With the engine at high idle and the load increased, the engine speed will decrease. The flyweights move in and the governor spring pushes the riser forward and increases the amount of fuel going to the engine. As the load is increased, the governor spring pushes the riser farther forward and the spring seat pulls on the stop bolt. The stop collar, on the opposite end of the governor, has a power setting screw and a torque rise setting screw that control the maximum amount of fuel rack travel.

(g) The power setting screw moves forward and makes contact with the torque spring. This is the full load balance port. If more load is added to the engine, the engine speed will decrease and push the riser forward more. This will cause the power setting screw to compress the torque spring until the torque riser setting screw makes contact with the stop bar. This is the point of maximum fuel to the engine.

(5) Governor Servo

(a) The governor servo gives hydraulic assistance to the mechanical governor force to move the fuel rack. The governor servo has a cylinder, a cylinder sleeve, a piston, and a valve.

(b) When the governor moves in the "FUEL ON" direction, the valve moves to the left. The valve opens one oil outlet and closes the other oil passage. Pressurized oil from the oil inlet pushes the piston and fuel rack to the left. Then oil behind the piston goes through the oil passage, along the valve and out the oil outlet.

(c) When the governor spring and flyweight forces are balanced and the engine speed is constant, the valve stops moving. Pressurized oil from the oil inlet pushes the piston until these two oil passages are opened. Oil now flows through this oil passage, along the valve, and out through the oil outlet. With no oil pressure on the piston, the piston and fuel rack stop moving.

(d) When the governor moves in the "FUEL OFF" direction, the valve moves to the right. The valve closes the oil outlet and opens the oil passage. Pressurized oil from the oil inlet is now on both sides of this piston. The area of the piston is greater on the left side than on the right side of the piston. The force of the oil is also greater on the left side of the piston and moves the piston and fuel rack to the right.

(6) Dashpot

(a) The dashpot helps give the governor better speed control when there are sudden speed and load changes. The dashpot has a cylinder, a piston, a dashpot spring, a needle valve and a check valve. The piston and spring seat are fastened to the dashpot spring.

(b) When the governor moves towards the "FUEL ON" position, the spring seat and piston move to the right. This movement pulls oil from the oil reservoir through the check valve into this cylinder.

(c) When the governor moves towards the "FUEL OFF" position, the spring seat and piston move to the left. This movement pushes oil out of the cylinder through the needle valve and into the oil reservoir.

(d) If the governor movement is slow, the oil gives no restriction to the movement of the piston and spring seat. If the governor movement is fast in the "FUEL OFF" direction, the needle valve gives a restriction to the oil and the piston and spring seat will move slowly.

(7) Air-Fuel Ratio Control

(a) The air-fuel ratio control is designed to restrict the fuel until the air pressure in the inlet manifold is high enough for complete combustion. It prevents large amounts of exhaust smoke caused by an air-fuel mixture with too much fuel.

(b) The stem moves the lever which will restrict the movement of the fuel rack in the "FUEL ON" direction only. With the engine stopped, this stem is in the fully extended position. Movement of the fuel rack and the lever is not restricted by the stem. This permits maximum fuel to the engine for easier starts.

(c) After the engine is started, engine oil flows through the oil inlet into the oil pressure chamber. From the oil chamber, oil flows through an oil passage to the internal valve and out the oil drain passage in the stem. The stem will not move until the inlet manifold pressure increases enough to move the internal valve. A line connects the inlet manifold with the inlet air chamber of the air-fuel ratio control.

(d) When the inlet manifold pressure increases, it causes the diaphragm assembly to move towards the right. This also causes the internal valve to move to the right. As the internal valve moves to the right, it closes the oil passage. With the oil passage closed, oil pressure in the oil chamber increases and oil pressure then moves the piston and stem to the left and into the operating position. The air-fuel ratio control will remain in the operating position until the engine is shut off.

(e) When the governor control is moved to increase fuel to the engine, the stem limits the movement of the lever in the "FUEL ON" direction. The oil in the oil chamber acts as a restriction to the movement of the stem until the air inlet pressure increases.

(f) As the inlet air pressure increases, the diaphragm assembly and the internal valve move to the right. The internal valve opens the oil passage, and oil in the oil chamber goes to the oil drain passage. With the oil pressure reduced behind the piston, the spring moves the piston and stem to the right. The piston and stem will move until the oil passage is closed by the internal valve. At this time the lever can move to let the fuel rack go to the "FULL FUEL" position.

(g) The air-fuel ratio control will remain with the engine when the injection pump is turned in for repair.

2. PROCEDURES REQUIRED TO REPAIR THE CATERPILLAR FUEL INJECTION PUMP

a. Procedures for repair of the Caterpillar fuel injection pump are contained in RS-08757A-50, Caterpillar Service Forms No. SENR2066, No. SENR2782, and this student handout.

b. Clean the Pump Before Disassembly

- (1) Clean the injection pump.
- (2) Explain to the instructor the procedure for cleaning the injection pump.

c. Preoverhaul Inspection

- (1) Inspect the injection pump.
- (2) Explain to the instructor the procedure for inspecting the injection pump.

d. Disassemble Injection Pump

- (1) Remove the outer governor housing and gasket from the pump housing.
- (2) Remove the governor spring, two wave washers, one flat washer, and seat from the guide.
- (3) Remove the throttle shaft cover and gasket from the governor housing.
- (4) Remove the seal from the cover.
- (5) Remove the low idle adjustment screw and spring from the housing.
- (6) Remove the two throttle shaft levers and shaft assembly from the housing.
- (7) Remove two snap rings, pins, plates, and stop from the shaft assembly.
- (8) Remove the throttle break pins, spring, throttle shaft, and air-fuel ratio lever from the governor housing.
- (9) Remove the insulator and dashpot body.
- (10) Remove the high idle screw cover and gasket from the governor housing.
- (11) Remove the seal and high idle adjusting screw.
- (12) Remove the inner governor housing and gasket from the pump housing.
- (13) Remove the torque group.
- (14) Remove the spacer, spring, and insulator from the torque group.

- (15) Remove the full load stop block from the housing.
- (16) Remove the collar and spring from the block.
- (17) Remove the governor servo from the injection pump.
- (18) Remove two locking rings, seat, broken link spring, and sleeve from the valve.
- (19) Remove the servo valve, sleeve, and piston from the governor servo.
- (20) Remove the bearing preload spring, thrust bearing, and sleeve from the governor shaft.
- (21) Remove the dashpot assembly from the governor shaft.
- (22) Remove the snap ring and spool from the seat.
- (23) Remove the outer seat from the dashpot spring and remove the spring from the inner seat.
- (24) Remove the overfueling spring and riser from the governor shaft.
- (25) Remove the ring, races, and bearing from the riser.
- (26) Remove the governor weight shield.
- (27) Remove the carrier, dowels, and weights from the shaft.
- (28) Remove the bearings and races from the camshaft.
- (29) Remove the timing pin cover from the pump housing.
- (30) Install the timing pin.
- (31) Remove the injection pumps from the pump housing.
- (32) Remove the spacers from the pump housing.
- (33) Remove the plunger and washer from the barrel and spring.
- (34) Remove the washer from the plunger.
- (35) Remove the spring from the barrel.
- (36) Remove the ring and barrel from the bonnet.
- (37) Remove the check assembly and spring from the bonnet.
- (38) Remove the rack from the housing.

- (39) Remove the lifters from the housing.
 - (40) Remove fuel manifold.
 - (41) Remove the snap ring from the camshaft.
 - (42) Remove the washer and camshaft from the pump housing.
- Have instructor initial.

e. Inspect Injection Pump Components

- (1) Find the procedures for inspection in RS-0875-7A-50.
- (2) Inspect the governor components.
 - (a) Inspect the bolts.
 - (b) Inspect all the covers.
 - (c) Inspect all the rings.
 - (d) Inspect the insulators.
 - (e) Inspect the valves.
 - (f) Inspect the dashpot body and plugs.
 - (g) Inspect the levers.
 - (h) Inspect the stop assembly.
 - (i) Inspect spring No. 2N2878.
Record reading. _____, _____.
 - (j) Inspect spring No. 4N6410.
Record reading. _____, _____.
 - (k) Inspect spring No. 7N7267.
Record reading. _____, _____.
 - (l) Inspect the governor flyweight carrier.
 - (m) Inspect the pins.
 - (n) Inspect the shaft.
 - (o) Inspect the governor housing assembly.

- (p) Inspect the guide.
 - (q) Inspect the bearings.
 - (r) Inspect the sleeves and seats.
 - (s) Inspect the dashpot.
 - (t) Inspect the riser.
 - (u) Inspect the races.
 - (v) Inspect the block assembly.
 - (w) Inspect the collar.
 - (x) Inspect the piston.
 - (y) Inspect the weight and carrier.
- (4) Inspect the pump housing components.
- (a) Inspect the camshaft.
 - (b) Inspect the lifters.
 - (c) Inspect the bushings.
 - (d) Inspect the bonnets.
 - (e) Inspect the check assembly.

NOTE: When there is too much wear on the fuel injection pump plunger, the lifter may also be worn and there will not be good contact between the two parts. To stop fast wear on the end of a new plunger, install new lifters when replacing the plunger.

- (f) Inspect the plunger.

Record reading.

- (g) Inspect the rack.
- (h) Inspect the deflector.
- (i) Inspect spring No. 7N1067.

Record reading. _____, _____.

- (j) Inspect the sleeves.
- (k) Inspect the pins and lever.

- (l) Inspect the piston.
- (m) Inspect the valve.
- (n) Inspect the bearings.

Record reading. _____, _____, _____,
_____.

- (o) Measure the camshaft bearing journal diameter.

Record reading. _____, _____.

- (p) Inspect the pump housing.
- (q) Inspect the pump covers.

Have instructor initial.

f. Assemble the Pump from Serviceable Components

NOTE: All pump parts must be completely clean before reassembly. All packings will have a film of clean oil applied to them before they are installed.

- (1) Assemble the injection pump housing.

(a) Install camshaft and rack bearings. If the camshaft bearings and rack bearings were removed, they would be installed at this time.

1 Using the driver group, install the camshaft bearing in the governor end of the housing with the junction (joint) facing towards the top of the pump housing. Install the bearing so it is .10 inch plus or minus .008 inch below the surface of the housing.

2 Install the rack bearing in the governor end of the pump housing until it is .282 inch plus or minus .005 inch below the surface of the housing.

3 Turn the other end of the pump housing up and install the second camshaft bearing with the junction (joint) in the bearing facing towards the top of the pump housing. The bearing must be installed so it is .039 inch plus or minus .010 inch below the surface of the housing.

4 Install the plate assembly on the drive end of the injection pump to install the second bearing for the rack. Use clean grease to hold the new rack bearing on the driver of the bearing installer.

5 Install the driver and bearing in the plate assembly, with the groove in the driver in alignment with the pin in the plate, and use a hammer to drive the bearing into position. The bearing will be installed to the correct depth when the shoulder of the driver is against the plate.

6 Remove the plate from the housing. The rack bearing must be installed so it is .010 inch plus or minus .010 inch below the surface of the housing.

- (b) Install the camshaft.
- (c) Install the washer.
- (d) Install the snap ring. Check end play, record reading.

Have instructor initial.

- (e) Install the lifters.
- (f) Install the rack.
- (g) Install the gasket and fuel manifold.

Have instructor initial.

(2) Assemble the fuel injection pumps.

- (a) Install the check spring onto the check assembly.
- (b) Install the check assembly onto the bonnet.
- (c) Install the bonnet onto the plunger barrel.
- (d) Install the ring.
- (e) Install the plunger spring on the barrel.
- (f) Install the washer onto the plunger.
- (g) Install the plunger into the barrel.

Have instructor initial.

- (h) Install the spacers into the pump housing.
- (i) Install the injection pumps into the housing.
- (j) Install the O-ring seat and bushing.
- (k) Install the timing cover onto the pump housing.

Have instructor initial.

(3) Assemble the governor.

- (a) Install the races and bearings onto the camshaft.

- (b) Install the flyweights and dowel pins.
- (c) Install the dowel pin in the governor shaft.
- (d) Install the carrier.
- (e) Install the shield.
- (f) Install the races and bearing onto the riser.
- (g) Install the snap ring.
- (h) Install the riser and overfueling spring onto the governor shaft.

(4) Assemble the dashpot.

- (a) Install the dashpot spring onto the dashpot seat.
- (b) Install the dashpot and spring connector seat.
- (c) Install the spool and ring.
- (d) Install the snap ring.
- (e) Install the dashpot assembly onto the governor shaft.

(5) Assemble the governor.

- (a) Install the retainer ring in the lower groove on the governor shaft.
- (b) Install the retaining sleeves, preload spring, and bearing onto the governor shaft.
- (c) Install the retaining ring.
- (d) Install the O-ring seal.
- (e) Install the servo piston and sleeve.
- (f) Install the servo valve.
- (g) Install the locking ring in the center groove.
- (h) Install the servo sleeve, broken link spring, and seat.
- (i) Install the locking ring.
- (j) Install the governor servo.

(k) Install the rack and torque riser adjusting screws.

(l) Install the governor block, spring, and collar on the housing.

(m) Assemble and install the torque control group onto the block.

Have instructor initial.

(n) Install the governor housing onto the pump housing.

(o) Install the lip type seal in the outer governor housing.

(p) Install the high idle adjusting screw.

(q) Install the O-ring seal on the housing for the dashpot adjustment.

(r) Install the body into the governor housing.

(s) Install the cover.

(t) Install the contact.

(u) Install the check valve, fuel ratio lever, and shaft.

Have instructor initial.

(v) Install the flat, curved throttle shaft spring.

(w) Install the throttle shaft pin and the throttle shaft pin holding pin.

(x) Install the throttle stop, plates, pins, and snap ring.

(y) Install the throttle shaft levers.

(z) Install the throttle shaft assembly.

(aa) Install the low idle adjusting screw.

(bb) Install the low idle spring.

(cc) Install the lip type seal into the shaft assembly cover.

Have instructor initial.

(dd) Install the governor lever cover on the housing.

(ee) Install the spring seat, wave washer, flat washer, wave washer, and spring onto the guide.

Have instructor initial.

(ff) Install the outer governor housing.

g. Perform the Test and Calibration Procedures for the Fuel Injection Pump

(1) Perform static adjustments.

(a) Adjust the air-fuel ratio control.

(b) Adjust the static fuel setting and torque setting.

Have instructor initial.

(2) Perform flow test.

STUDENT REFERENCES:

RS-08757A-50

Caterpillar Service Form No. SENR2066

Caterpillar Service Form No. SENR2782